Coupling between erosion and weathering at hillslope, watershed, and global scales

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The ability to decipher links among tectonics, topography, physical erosion, and chemical weathering is required to solve a range of geoscientific problems, including evaluating whether mountain uplift influences climate by enhancing silicate weathering and CO_2 drawdown. Elucidating the nature of the relationship between erosion and weathering is central to evaluating this hypothesis, as models predict weathering rates diminish at rapid erosion rates. However, making measurements in such settings is logistically and analytically challenging.

Hillslope-scale work using *in situ*-produced ^{10}Be and Zr mass balance in soils from one of Earth's most tectonically-active landscapes, the western Southern Alps of New Zealand, show that erosion and weathering rates are linearly coupled, at the highest rates yet measured [1]. The linear relationship is consistent with previous work in landscapes with slow to moderate erosion rates, suggesting that chemical weathering of hillslope soils is limited primarily by the rate minerals are supplied by erosion. Watershed-scale suspended sediment and solute flux data indicate erosion and weathering are coupled across a large range of erosion rates, but become decoupled in Earth's most rapidly uplifting landscapes due to the increased delivery of relatively unweathered material to fluvial channels by landsliding, which dominates the erosion budget of such regions. Global-scale GIS modelling indicates that >50% of total denudation and 40% of chemical weathering occur on the steepest 10% of Earth's surface [2], indicating the delivery of dissolved constituents to the world's oceans is sensitive to mountain uplift.

Given this sensitivity, we have initiated more process-based work in the Southern Alps and will present initial results from our efforts to better understand the partitioning of weathering reactions as a function of depth within the Critical Zone and to trace the source of Ca in rivers, where loads are among the highest on Earth.

[1] Larsen *et al.* (2014) *Science* **343,** 637-640.
[2] Larsen *et al.* (2014) *Geology* **42,** 527-530.